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Contents

Conquest of the Killers

THIS ISSUE marks the beginning of our third volume and by the time you have got around to reading this editorial you will be aware that we have a new look. We hope that the appearance is not only more attractive and eye catching but also neater, cleaner and easier to read. It will also be noted that we are starting two series in this issue.

The first article in the series on disease vectors and their control, namely the "Economic Importance and Control of Tsetse Flies" by W. A. Page, gives an indication of our reason for publishing this series. The article shows us that before efficient control measures can be determined it is important to study in detail the biology, habits, life history and ecology of the disease vector concerned. Another important factor to be considered is that in the past the study of these vector borne diseases was somewhat disjointed due to the fact that the efforts of entomologists and ecologists studying the arthropod vectors, the doctors investigating the human diseases, the veterinarians attempting to cure livestock ailments, and the parasitologists seeking out the agents causing the disease, were unco-ordinated.

It is now realised that for vector born diseases to be combatted successfully the relationship between the parasite, host and vector must be considered as one system to be tackled accordingly; doctors veterinarians, entomologists, ecologists, parasitologists, agriculturalists, social workers, and others must pool their knowledge so that the world can be freed of some of the worst scourges of mankind such as sleeping sickness, malaria, bilharzia and filariasis. We hope that this series will be of some help to the scientists and technicians who are working on these international problems.

The second series to start in this month concerns the chemicals used in wood preservation. The introductory article by Mr. Bruce, Secretary of the B.W.P.A. is a semi-historical account designed to provide a background to the articles to follow. Each of the subsequent articles will deal with one of the chemicals used in the preservation of timber and it is hoped that the articles will be of particular value to operating companies in the wood preservation field.

A helicopter shows its paces as it distributes insecticide over rough country in Zululand.

THE ECONOMIC IMPORTANCE AND CONTROL OF TSETSE FLIES

By W. A. Page*

This article is the first in our series on disease vectors and their control. In the following account the author informs us that human and animal sleeping sickness has been one of the major barriers towards the development of Africa. The economic importance of trypanosomiasis, and methods of controlling it by the attacking tsetse flies, the sole vectors of the disease in Africa, is discussed.

ALTHOUGH there are many reasons why, in the past, Africa has been one of the most underdeveloped parts of the world, the tsetse fly, vector of trypanosomiasis, is certainly one of the prime causes and even today remains one of the barriers to progress. Writings in the fourth century record a sickness that made its victims sleep—almost certainly a reference to trypanosomiasis. Livingstone in his travels tells of the fierce attacks of the tsetse and of the damage these flies caused amongst his pack animals. Veterinary typanosomiasis must have occured for centuries, for the nomadic cattle-owding tribes have learnt to avoid tsetse areas, lest their cattle become sick. Human trypanosomiasis occured in epidemics from time to time, and then spread extensively as more peaceful times made travel safer and the population dispersed into hitherto uninhabited country.

*Department of Zoology, Edinburgh University.

The Genus *Glossina*.

There are twenty-two species of tsetse, all members of the genus *Glossina*. They are found only in tropical Africa, between the latitudes 14°N and 22°S, from the Atlantic seaboard to the Indian Ocean. The range of the various species overlaps to a great extent, but generally speaking each species has its own requirements as regards vegitation and climate, so that all types of vegetation from dry thorn bush to tropical rain forest will support one or more species of tsetse.

G. palpalis is the most widespread species, being found in riverine forest within fairly dry savannah (45ins rain per annum, with five rainless months.) and through progressively thicker vegetation to dense rain forest in West, Central and East Africa; a number of subspecies can be recognised within the species. *G. morsitans* is also widespread, but is confined to savannah woodland and does not penetrate forested areas, whereas the larger tsetse like *G. tabaniformis* and *G. hanningtoni* are found only in the rain forest, and *G. caliginea* only in mangrove swamps. This variety of habitat means that one method of control will not necessarily be suitable for all species or for all habitats of one particular species.

Although differing so widely in habitat, all species so far studied are remarkably similar in the length of their life cycle. They are all viviparous, the females depositing one full-grown larva at a time on suitable

soil. This larva burrows rapidly into the ground and pupates there, one half to one and a half inches below the surface. The adult emerges and forces its way upward to the air. At normal tropical temperatures (about 25°C) the larvae are produced at the rate of one every ten days, the pupal stage lasting about 4 weeks; these larval and pupal periods will be extended in cold weather. This is a very slow rate of reproduction in comparison with most flies in the Muscidae, but tsetse do not suffer the high larval mortalities experienced by other Muscid flies and the mortality of tsetse pupae is generally low, although in some places high parasite rates have been found.

The length of adult life is not easy to determine under natural conditions. Marking experiments have given for *G. palpalis* estimates of 27 days average life for males in Kenya;[7] in Nigeria, it was found that over 51% of female flies live over two months and the greatest age attained by flies kept in tubes in the natural habitat was 233 days. Hence individual flies may live as long as 8 months, but the more usual would be 2-3 months. Many flies (about 25%) die in the first 20 days of life and the survival of the remainder depends upon the climate, mortality being heavy in hot dry seasons of the year and possibly during very wet seasons also.[12]

Human Trypanosomiasis.

There are two types of human sleeping sickness, caused by two species of trypanosome. The gambian type, caused by *Trypanosoma gambiense*, occurs in West and Central Africa and around Lake Victoria in East Africa. It is a chronic disease and the symptons at first are mild. Eventually the trypanosomes invade the central nervous system of the patient, who becomes increasingly lethargic and "sleeps" almost continuously. He dies, not usually of the sleeping sickness, but from a secondary infection such as pneumonia or dysentery. The interval between the infected tsetse bite and death will be many months or even years, so that there is full opportunity for the diagnoses and treatment of the disease in its early stages.

The Rhodesian type of sleeping sickness, caused by *Trypanosoma rhodesiense*, occurs in East and Central Africa in small isolated areas, and is an acute disease. The period from the onset of the disease until death may be as short as two weeks, which makes diagnosis and treatment more difficult. It is a rarer disease than the Gambian form, but its virulent nature and the occurrence of epidemics make it a source of danger to man.

Deserted villages in many parts of Africa still tell of the ravages caused by sleeping sickness. This is particularly true of East Africa: in Tanganyika alone, 23,955 cases of Rhodesian sleeping sickness were diagnosed between 1922-46, and of these 11,500 died. The number that died without being seen by a doctor is not known, but must be large. In 1929, 3,262 cases were diagnosed,[6] so deaths were possibly over 2,000 in that one year. In West Africa depopulation has also occurred, but to a lesser degree—the disease has caused a general drain on the population.

Sleeping sickness is less of a menace now than previously. By use of tsetse control methods and improvements in drug therapy, combined with survey among susceptible populations, the disease is under control in most areas, sporadic outbreaks occurring from time to time. For example, in Nigeria in the thirties, surveys showed that 20% of the people examined were infected: this figure has now been reduced to 0.02%. Over the whole of Africa, the incidence of *T. gambiense* has dropped from 6.93 new cases per 10,000 of population in 1948 to 1.63 per 10,000 in 1957.[19] It must be emphasised that the disease is only controlled, not eradicated and if the constant vigilance now exercised by government departments in sleeping sickness areas is relaxed, then the disease may well return to its former incidence. Under present circumstances, Gambian sleeping sickness, in spite of its wide distribution, is less of a danger than the Rhodesian type which kills so much more quickly. In the territories in which it occurs Rhodesian sleeping sickness has fluctuated in the ten years 1948-57 between 0.60 cases per 10,000 population in 1949 and 0.29 cases per 10,000 in 1956.[19]

Animal Trypanosomiasis.

It is not possible to give figures for the number of cattle that die as a result, either direct or indirect, of animal trypanosomiasis, since the majority of cases are not reported. These losses must be considerable and occur in areas where tsetse challenge is comparatively light. Where tsetse challenge is heavy, no cattle can be kept at all. Although not all the 40,000 sq. mile where tsetse occur could be used for cattle rearing, because of poor pasturage, lack of water, etc., there are vast areas where cattle could thrive were it not for the tsetse. This deprives the country of valuable export assets in hides, horn and other animal products and also deprives the local population of meat, milk and dairy products, with the result that in many areas the African's diet is deficient in protein. Also, the farmer is deprived of manure for his land and is forced to follow the wasteful practice of shifting cultivation, using one piece of land for crops for a year or two and when the land is exhausted, moving on to another area. With the increase in population following upon improved medical services, available land is becoming scarcer and the fallow periods shorter and shorter, so that barrenness, erosion and other effects of bad farming are becoming more common. Animal manure could

do much to alleviate this situation.

There are of course large areas of tropical Africa that are, for one reason or another, free of tsetse and here cattle can be kept successfully, although exposed to other endemic diseases. There are some dwarf breeds of cattle that are resistant to trypanosomes. These can be kept in some tsetse areas, but they are not an economic breed and do not seem to be the answer to the problem.

Economic Importance of Various Species of Tsetse.

G. palpalis and *G. tachinoides* are both carriers of Gambian sleeping sickness. Both are riverine tsetse, that is they inhabit the thicker evergreen forest that lines the streams flowing through the savannah woodland. *G. tachinoides* can tolerate drier conditions than *G. palpalis* and so extends into more arid regions. *G. palpalis* also extends into wetter regions and there loses its riverine habit. Although these flies live in the cooler riverine forest, they are under considerable stress during the hot, dry times of the year. Then they can only survive in the thickest parts of the forest, and, in the case of *G. palpalis* near the drier extremity of its range, in the presence of pools of water in the otherwise dried-up stream bed. A feature of the transmission of sleeping sickness by these flies is the extremely small number of flies, usually under 1%, that are infected with *T. gambiense* in nature. It would therefore appear that it is a few flies in close contact with man that spread the disease—the situation where man is dependent upon a pool for his water in the dry season and the tsetse is dependent upon the same pool for its survival is ideal for the spread of sleeping sickness. In regions of higher humidity, this intimate contact between man and fly is lost, so that sleeping sickness is absent, even though the vector is present.

Both these species of tsetse also carry animal trypanosomes. Here again the infection is usualiy light, although the rates vary from place to place: for *G. palpalis*, figures of 11% have been recorded from the Belgian Congo,[2] 4.3% from Sierra Leone[18] and from Nigeria 3% in the North[12] and 2% in the South[14] of the country. With the low levels of infection, cattle can be kept in the presence of these tsetse although there will be some losses from trypanosomiasis.

G. morsitans is the carrier of Rhodesian sleeping sickness. Man is not a favoured host of this fly and the causes of its acting as a vector are still somewhat obscure, although the recent proof of the theory that some game animals can be a reservoir of *T. rhodesiense* may throw fresh light upon this problem.[8] *G. morsitans* is found widely dispersed through the savannah woodland, but in parts of its range it has to retreat to thicker forest to survive during the hot, dry times of the year. This fly occurs in well-defined areas called "fly-belts", the term "well-defined" being used in a cartographical sense, as it is often difficult to discover just what makes a certain area of bush acceptable to the fly. In some places the fly does choose a definate vegetational zone, but in others there may be a fly-belt alongside a fly-free zone that appears to be identical in every respect. The reasons for this are not yet known.

G. morsitans over the whole of its range is a very efficient carrier of the trypanosomes effecting domestic animals. The infection rate of the fly in nature is high, ranging from 10% up to 40%, so that where this fly occurs, cattle cannot be kept except by the use of prophylactic drugs.

G. longipalpis is found in West Africa and N.W. of the Congo. These flies are also efficient carriers of animal trypanosomes, natural infection rates of 25-33% having been recorded.[13] As the species inhabits transitional zones and savannah woodland in the wetter areas, it is of great economic importance and prevents much pasture land from being used for cattle grazing.

G. pallidipes is found on the eastern side of Africa. In some restricted areas this fly carries sleeping sickness, and also animal trypanosomiasis. Infection rates so far recorded are low, in the order of 2-4%.[2] It has a very widespread but patchy distribution through a wide range of vegetational types and climatic conditions; seemingly small areas of thicket are a requirement for its presence.

G. swynnertoni, found in Tanganyika and Kenya is similar to *G. morsitans* in habits, but inhabits the drier thorn bush. In some areas it carries sleeping sickness, but is more important within its limited range as a vector of animal trypanosomes, infection rates of 11% having been recorded.[2]

G. medicorum, *G. fusca* and *G. nigrofusca* are forest dwelling tsetse, but they can penetrate into the savannah by using the protection of riverine forest and forest outliers. They show high infection rates of 14, 15 and 25% respectively.[15]

Of the remaining species, *G. austeni* and *G. brevipalpis* are of local importance. The remainder either inhabit forest that could not be used for stock-raising or are of minor importance.

Control of tsetse.

Owing to the importance of protecting the human population against sleeping sickness, research into the control of tsetse was directed towards the carriers of this disease and remained concentrated upon this problem until after the last war when the equal importance of veterinary trypanosomiasis was acknowledged.

Control by Clearing.

As far as the vectors of sleeping sickness are concerned, no successful method of dealing with *G. morsitans* was

found, but it was shown that *G. palpalis* and *G. tachinoides* could readily be eradicated in sleeping sickness areas by clearing of vegetation along the streams, thus prohibiting the survival of the tsetse in the riverine forest during the dry season. At first it was considered necessary to cut down *all* the vegetation—tall trees, shrubs, climbers and herbage—leaving just stumps of trees, over which were piled the cut-down branches. These heaps of trash were fired when dry, so that the stump should be killed. This method is known as ruthless clearing.

More detailed work on the bionomics of tsetse showed that to achieve the same result, it was only necessary to remove the shrubs, thickets and, most important, the curtain of creepers that clothed the outside of the forest. This removed the "insulating" layers of the vegetation and destroyed the cooler, more humid ecoclimate, so that the flies did not survive the dry season. Flies could survive there during the rains—indeed a cleared forest with good visibility under high shade forms an excellent feeding ground for tsetse; it is therefore necessary that precaution be taken against the infiltration of tsetse from uncleared areas.

This process of removing only certain parts of the vegetation is known as partial, discriminative or selective clearing: there are slight differences between these three types, but the underlying principles are the same. These methods are most widely used, ruthless clearing being reserved for protection of road crossings, isolation of areas where tsetse are being eradicated by other methods and to stop advances of tsetse into fly-free areas.

Clearing has the advantage that it is effective. It has some disadvantages. It entails the destruction of forest products, such as roofing poles, lianes for ropes, etc. It has been said that clearing the forest would lead to increased erosion round the stream. In practice this has found to be not so. Clearing reveals existing but hitherto unsuspected erosion, but as the cleared areas are rapidly colonised by grasses, this existing erosion does not spread and no new erosion takes place. Another disadvantage is the rapid regeneration under tropical conditions of the cleared vegetation, even in spite of burning after clearing. This means that the regrowth in cleared areas must be reslashed at, initially, yearly intervals and subsequently maintained—a very arduous undertaking when possibly thousands of miles of stream are involved.

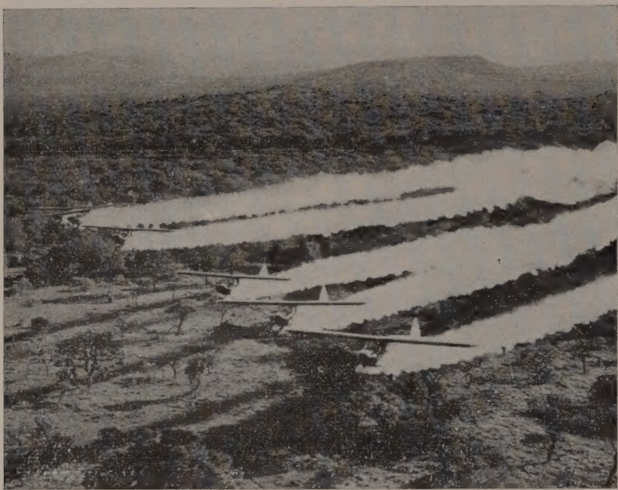
The greatest drawback to clearing nowadays is its cost. When this method was first introduced, wages were low and free community labour easily obtainable. Now with wages at a higher level and less free labour obtainable, costs of clearing are very high. In Nigeria, for example, the cost has risen from about £11 per mile in 1941[11] to £100 per mile in 1957[4] for partial clearing of streams.

Bush clearing in Zululand.

The clearing method can be used against *G. morsitans* at the hotter and drier end of its range, where it depends for its survival in the dry season upon relict forest islands and riverine vegetation. But it is of no use in the greater part of this species' range where it can survive the shorter and less severe dry season in the savannah woodland. However, in parts of Northern Rhodesia it was found that a comparatively narrow belt of vegetation, an "interzone" between the miobo woodland and the grassy floors of the valleys, was essential to this fly, and when this interzone was felled, the fly was eradicated. This very successful measure would not be applicable to most areas where *G. morsitans* occurs, but it does indicate the importance of detailed work on the tsetse before attempting control measures.

G. morsitans will not live in the absence of game animals and in some parts of Africa, notably Southern Rhodesia and Uganda, fencing to exclude game and game eradication have been used as control measures, the former with limited success, the latter with varying degrees of success. Fencing should provide an answer to game control, but the areas to be considered are so vast and the practical difficulties so great that it can be discounted as a practical method.

Game eradication, although the idea is abhorrent to many people, is of great value. It takes about five years to clear a belt 20-30 miles wide of game with the subsequent disappearence of *G. morsitans*.[3] If after a further two years, no fly has been found and no cases of trypanosomiasis have occured in test herds of cattle in the area, then it is considered as fly-free. Game eradication does not have any effect on *G. palpalis* and *G. tachinoides* since these flies can exist on a diet of human and reptilian blood. Against other species of tsetse this method has not been sufficiently tested to estimate its success; in Uganda, however, *G. pallidipes* as well as *G. morsitans* was eradicated by a programme



Combined operations as six planes lay a swathe of insecticide over Zululand bush.

of game shooting combined with a small amount of clearing.[17]

It is important game destruction should be well planned after surveys of the area concerned by entomologists and game wardens and should be controlled by a competent authority, otherwise much needless slaughter and suffering to wild animals will result without any benefit resulting to the human population.

Insecticides.

When residual insecticides became available and were used widely against various pests, they were not used against tsetse, because some small trials with DDT did not indicate that they would be more effective and economic than the methods of control then in use. With rising costs however, and the increasing attention being paid to animal trypanosomiasis, the vectors of which could not easily be controlled, more use has been made of insecticides such as DDT and BHC.

There are several biological factors to be considered in this connection. The pupae are buried in the ground, so that only the adult stage can be attacked. The pupal period is fairly long (1 month in warm weather, 2 months in cold) and the young female can deposit her first larva after two weeks: hence the residual effect of the insecticide must be long-lasting or repeated applications must be made in order to kill the young flies emerging from the pupae before they themselves have deposited larvae. Tsetse flies occupy large areas of country, and unless a treated area is isolated, then reinfestation will take place.

Spraying from the ground against riverine tsetse, *G. palpalis*, has been tried in Kenya.[21] The riverine vegetation was sprayed from knapsack sprayers by labourers walking along the stream bed. 13.8lbs. of 50% DDT powder per mile was applied four times in four months. This reduced the tsetse from 660 flies caught in January before the start of the operation, to 17 flies in April. Heavy rain then fell and made spraying difficult and it was also found that the area had been insufficiently isolated. However, results were very encoutaging; costs were £15-17 per mile as against £250-350 per mile for clearing.

Spraying of vegetation against riverine tsetse has also been tried in Nigeria.[4] Here, use of 22.7-72.7lbs. per mile of DDT and 50% wettable powder in a 5% or $2\frac{1}{2}$% solution applied by knapsack sprayers, giving 4 applications at 14 day intervals, gave eradication of *G. palpalis* at a cost of £50/10s per mile as against £100 for clearing.

Spraying against *G. morsitans submorsitans* has been carried out in Nigeria.[10] This experiment was conducted in an area at the hot, dry end of the species' range where the flies retreat to forest islands during the dry season. These forest islands were sprayed with a 5% suspension of DDT wettable powder at a rate of 20lbs. per acre. One application only was given in most places (two were found necessary in two places) and resulted in the eradication of *G. morsitans*. *G. tachinoides* in the same islands was reduced in numbers but not eradicated. 200 acres of forest were sprayed, this treatment freeing from tsetse an area of 7 sq. miles, at a cost of £700. It was estimated that clearing the area would have cost £6,000. It does not follow that a similar success would be obtained in more humid areas, where concentration of *G. morsitans* in the dry season is not so complete.

Aerial Spraying

As the areas infested with tsetse are so large, aerial spraying would appear to be indicated. This has been used with success in South Africa where *G. pallidipes* was eradicated from an area of 7,000 sq. mls. in Zululand[5] The area was 450 miles from the next fly-belt. Surveys revealed that although adult flies were found all over the fly-belt, breeding (i.e. larval deposition) was taking place only in three game reserves, covering a total area of 200-250 sq. mls., the adults dispersing from these sites to the rest of the 7,000 sq. mls. It was therefore necessary to treat only the breeding sites, and various methods, including DDT sprays from the air, smoke generators and dusts from the ground, were tried. Finally, BHC used as a fog or thermal aerosal applied by Piper Cruiser aircraft over level ground or by helicopters over hilly country. Eight applications were considered necessary at 3-4 weekly intervals, starting the campaign just before the fly population reached its annual peak. The insecticide (4% BHC solution in oil) was delivered at the rate of 1.3 gallons to 15 acres from the Piper, and 3.3 gallons to 17 acres from the helicopter. This was backed up by a limited amount of discriminative clearing and dipping of all

cattle in the area in a DDT dip (this was also being used for tick control).

Costs

Costs of this campaign in Zululand amounted to 9/- to 10/- per acre (£288-320 per sq. mile) but this figure includes a large amount of research and testing. It is estimated that using the most efficient and economical methods tested, costs would have been as low as 10.6 pence per acre (£28 per sq. mile) for the cost of aircraft and insecticides. This does not include capital expenditure, labour or transport costs, which would at least double the cost; also these were the prices in 1949—no doubt they would be higher today. The figure of 10.6 pence per acre is the cost of ridding 7,000 sq. miles of tsetse; the cost per acre of the actual spraying (8 applications) of the breeding areas would be 10/4d. per acre (£330 per sq. mile) for the Piper and £1-3s-4d. per acre (£742 per sq. mile) for the helicopter. Thus in places where breeding takes place over a large proportion of the fly-belt, costs are likely to be high.

In addition to *G. pallidipes*, *G. brevipalpis* and *G. austeni* occured locally where the vegetation was suitable. Although *G. brevipalpis* was eradicated in one area, neither species was entirely eradicated; indeed eradication was not aimed at because these flies occur in pockets all the way from Zululand to Portuguese East Africa, and they were not considered to be a threat to stock, owing to their localised habit and feeding behaviour.

A great deal of research on aerial spraying against tsetse (and other insect vectors) has been undertaken by the Colonial Insecticide Research Unit in East Africa.[9] Not only have the effects on tsetse been studied but also the technical aspects of the method. In dense forest areas, spraying from the air does not seem to be very successful against *G. palpalis*, using 0.2lb. per acre of *pp*' DDT or 0.032lbs. of gamma BHC per acre. Best kills were obtained when these insecticides were used as aerosols.

Further experiments against *G. morsitans* and *G. swynnertoni* in savannah in various parts of East Africa met with varying degrees of success. Costs using 0.25 gallons per acre of a 10% w/v solution of technical DDT would work out at 29/- per acre or £1,000 per sq. mile. More recent work using dieldrin at the rate of 1 pint per acre of a 5% solution has given promising results at a cost of £350 per sq. mile.

From the foregoing, it is apparent that aerial spraying is a feasible method of tsetse control. Its drawbacks would seem to be the restricted time in which meteorological conditions are suitable for spraying—perhaps one hour after dawn on 15 days per month during the dry season—so that men and machines are idle for long periods, thus raising costs, the nature of the vegetation, which may be of such formation as to prevent the penetration of the insecticide to the lower levels and the irregularity in size and topography of the terrain.

Ground Spraying

Ground spraying would seem to be a good method of control in certain areas. Provided the right time of year is chosen, meteorological conditions do not hinder ground spraying operations, but the thickness of the vegetation and the difficulties of the terrain may well do so.

Before planning an insecticidal programme it is essential that accurate surveys of vegetation, topography etc. should be made so that maximum efficiency at minimum cost may be obtained and the most economic method chosen. Important also is the isolation of the area, so that no flies may recolonise the sprayed areas from untreated parts. So many experiments have not been completely successful because of the incomplete isolation of the experimental area.

One aspect of overall spraying of this nature that may cause concern is the possible effect on other fauna

Photo: courtesy Shell

Dieldrin being sprayed by the Tsetse Control Unit in Northern Nigeria.

in the area. No precise work on this problem has, as far as I know, been undertaken. Du Toit,[5] considers that although large numbers of insects are destroyed, after the spraying is stopped the area is recolonised fairly rapidly from the surrounding untreated area. Certainly tsetse will recolonise a sprayed area, but on the other hand, if tsetse are eradicated it is fairly certain that other species will be eradicated also. It is questionable whether the effect of spraying will be any worse than the effects of clearing which alters the habitat and makes it untenable for thousands of insects and other animals.

There is a definite need for information that will enable insecticides to be applied to more restricted parts of the tsetse's habitat, where it will be fully effective. Current work to discover the places where tsetse rest at night (when they are inactive) may give such information and lead to more precise methods in the use of insecticides. For example, in Nigeria recoveries of marked *G. palpalis* have shown that about half the flies rest at night on leaves and twigs within a foot of the ground. Spraying only broad leaved bushes up to two feet from the ground with dieldrin has given encouraging results, but more time is needed before these can be fully assessed.[20]

Use of Sterile Males

The success of the campaign in Curacao to eradicate the screw-worm fly by release of male flies rendered sterile by gamma rays[1] suggests the use of this method against tsetse. If pupae of *Glossina* are exposed to gamma rays, the males that emerge are nearly all sterile, but will copulate with females, who do not then copulate again and of course cannot produce offspring.[16] This method would appear to offer a neat solution to the tsetse problem, but unfortunately enormous numbers of sterile males would be required for release, since they have to compete with wild fertile males, and the practical difficulties of rearing the number of flies required seem at present to be an insurmountable barrier.

Discussion

Tsetse control programmes should form part of a wider programme of land use. Where areas have been cleared of tsetse, the settlement of new populations will consolidate the position, as game will be hunted and driven away and land cleared for use as farms. *G. morsitans* for example will not stay in places where the population density is over 40 per sq. mile. Some parts of Africa are over populated; movement of population to the extensive underpopulated areas is desirable from many aspects. No one would under-emphasise the human problems involved in trying to move people into new areas, but one cannot over-emphasise the importance of doing so.

The final solution of the trypanosomiasis problem is still many years ahead, but considerable advances have been made in the last 30-40 years. It is not possible, in the present state of our knowledge to say in which direction the final answer will be found. It seems likely that no single measure will alone rid Africa of human and animal trypanosomiasis, but that a combination of tsetse control by clearing and insecticidal method, the use of prophylactic drugs for domestic stock, early treatment of cases of human sleeping sickness, together with improvements in agriculture and land use, and increasing population, will reduce both these diseases to a negligible incidence.

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Photographs on pages 4, 7 and 8 courtesy of Dr. René du Toit, Director of Veterinary Services, Onderstepoort, S. Africa.

PNEUMATIC KNAPSACK SPRAYERS FOR USE IN STORAGE PREMISES

In this article the authors describe an investigation into the efficiency of pneumatic knapsack sprayers paying particular attention to the problem of obtaining an even deposit of insecticide with the use of water dispersible powders. It is suggested that reasonable results may be obtained by using a pressure-retaining sprayer fitted with a pressure regulating valve.

By G. T. Bills and A. A. Green*

KNAPSACK SPRAYERS which are widely used for the application of liquid formulations of insecticides, are portable, simply constructed and very suitable for small-scale treatments. They can be broadly divided into two types: hydraulic sprayers, which need to be pumped continuously with one hand during spraying while the lance is held in the other hand, and pneumatic sprayers (sometimes called compression sprayers) which are pumped to a defined working pressure before spraying begins and can, therefore, be operated with one hand.

Since the introduction of synthetic insecticides having residual toxicity, there has been a requirement for a small machine to apply insecticides to the internal fabric of warehouses and, sometimes, to the outer surface of stacks of commodities. It is important that such a machine should allow the operator one hand free while climbing ladders or negotiating obstacles. The pneumatic knapsack sprayer has proved useful in this field but has been found to give variable deposits. It seemed likely that these variations were related partly to falling spraying pressures and partly to the sedimentation of solids when water-dispersible powders were used. It was possible also that there was a differential settling rate between the active ingredient and the inert carriers in dispersible powders. An investigation of these factors has been made using water and a DDT water-dispersible powder in two types of pneumatic knapsack sprayer.

* Pest Infestation Laboratory, Agricultural Research Council

Types of Pneumatic Sprayer

Pneumatic sprayers depend for their energy source upon compression of air above liquid in a sealed container. A hand-pump is the usual means of air compression although some machines have provision for connection to a compressed air supply.

With one type of pneumatic sprayer, subsequently referred to as the standard pneumatic sprayer, air is pumped in after the machine has been charged with liquid. The air pressure falls rapidly during spraying so that further pumping is usually required before all the liquid has been expelled. Any remaining compressed air must be released before the container can be recharged with liquid.

With the second type of machine, the pressure-retaining unit, the air is compressed in the machine before charging with liquid and is retained by a valve system. The liquid is pumped into the container against the retained air pressure which is thereby raised to the spraying pressure. During spraying, pressure falls gradually to the retained air pressure by which time all the liquid has been expelled. This type of machine is less simple in design than the standard type and is, therefore, more expensive but has advantages in that,

once charged, it sprays until completely empty and is less tiring to charge with liquid than is the standard type to charge with air.

Experimental Details

One commercial machine of each type was used in the tests; each had a working capacity of about 2 gal. and was of a kind commonly used in practice. The same short-range hand lance fitted with a ceramic fan nozzle was used on each machine. When a pressure-regulating valve was used, it was interposed between the container and the spray lance and was set to give a spraying pressure of 30lb. per sq. in. at the nozzle. At this pressure the water output with the nozzle used was about 1040ml per min. (1.83 pints per min). This combination of pressure and spraying rate is similar to that recommended by Burnett and Woodcock [1] and has been found in practice to be satisfactory for the application of spray films at the usual rate of 1 gal per 1,000 sq. ft. of surface. Sprayers and accessories were used according to the manufacturers' recommendations.

Tap water alone was used for the comparison of spraying rates. The water-dispersible powder was stated to contain 50% technical DDT, 43% insoluble carrier and 7% wetting agent and is a standard, commercial product. It should be emphasised that the product used in these experiments was chosen because it settled out of suspension relatively quickly and was, therefore, well suited to demonstration purposes. For use, it was creamed with a little tap water, diluted to give a 4.4% w/v dispersion and thoroughly stirred. The suspension, now 4.1 % w/v with the wetting agent in solution, was agitated by an electrically-driven paddle to prevent the separation of solids before or during filling operaions.

After charging the pressure-retaining unit with air at 40lb. per sq.in., liquid was pumped in until the pressure within the container was 90lb. per sq.in. This gave a liquid charge of about 8660ml (15.25 pints). The standard sprayer was charged with the same amount of liquid and pumped to its prescribed, initial pressure of 75lb. per sq.in. Operations for both machines were timed so that mixing, stirring and filling took 5 mins. and spraying began 3 min. after stirring had ceased.

During spraying, the nozzle was moved along a row of glass jars so that each vessel collected spray for 30 sec. The spraying pressure at the nozzle was noted as it was moved to each fresh jar. The pressure-retaining unit was operated for about 7 min. i.e. until empty and the standard sprayer for 10 min., by which time the output was reduced to a trickle. The 30 sec. samples were measured and the suspensions filtered. The residues were then conditioned to a constant weight under the

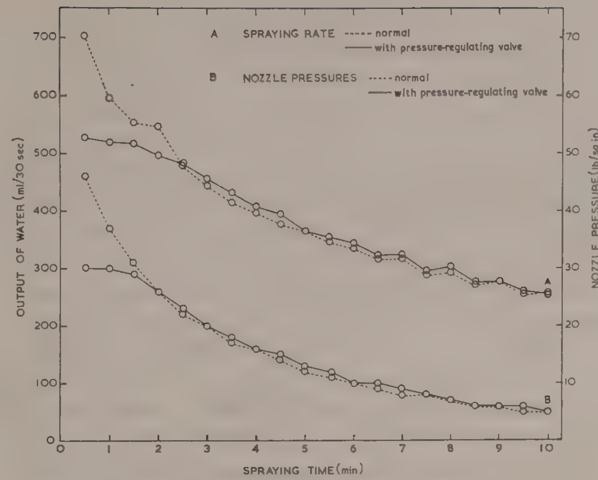

Fig. 1. Standard pneumatic sprayer.

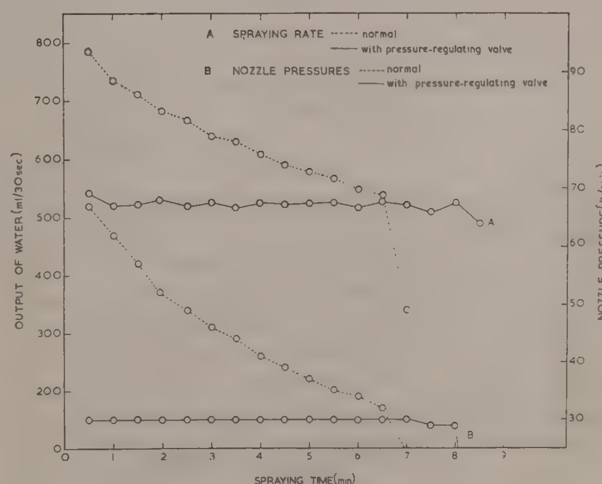

Fig. 2. Pressure-retaining pneumatic sprayer.

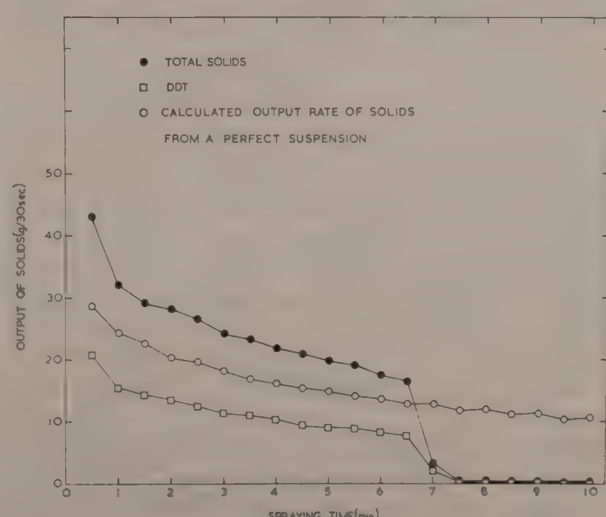

Fig. 3. Suspension sprayed by standard pneumatic sprayer.

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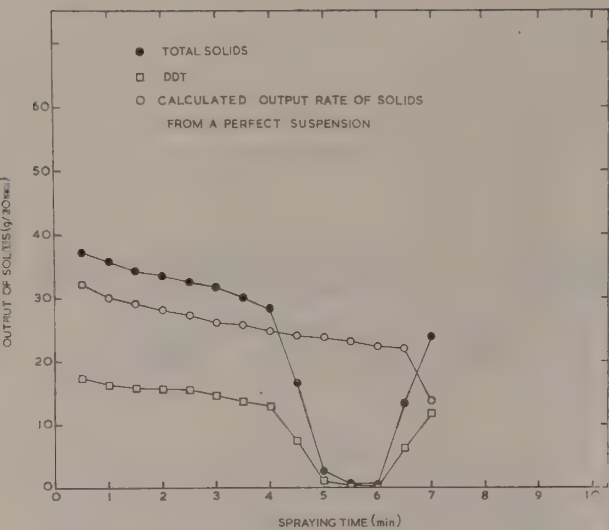

Fig. 4. Suspension sprayed by pressure-retaining pneumatic sprayer.

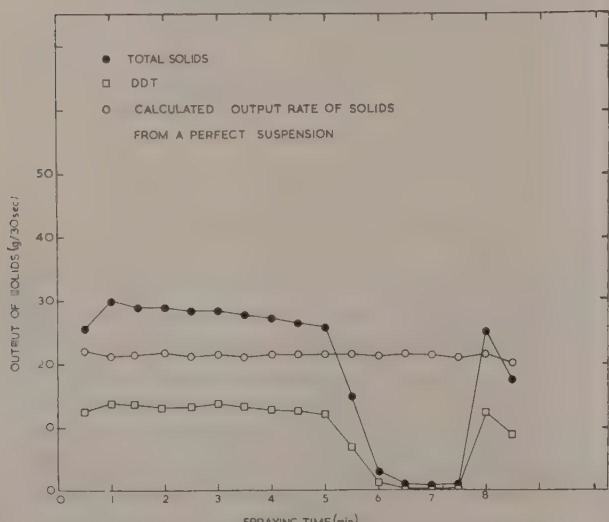

Fig. 5. Suspension sprayed by pressure-retaining pneumatic sprayer fitted with pressure-regulating valve.

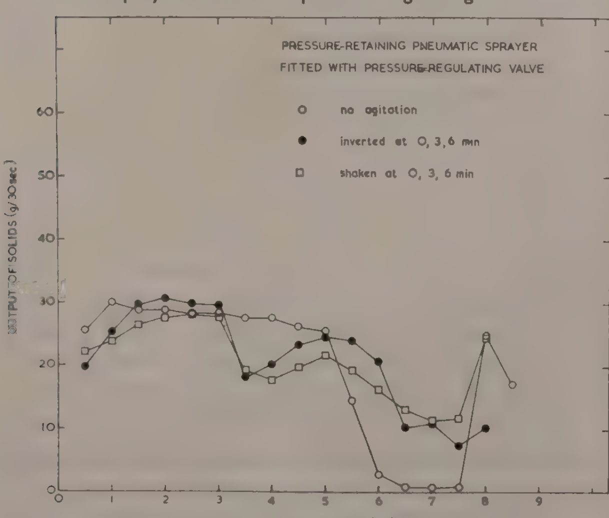

Fig. 6. The effect of agitation on the output rate of solids.

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conditions of relative humidity used for storing the original powder.

In order to determine whether there was a differential rate of settling between the toxic ingredient and the remaining insoluble solids, the DDT content of the residues was determined by refluxing for at least 15 min. with a suitable excess of benzene, followed by filtering, reconditioning and reweighing.

The possibility was investigated that vigorous movement of the machine would reduce the degree of sedimentation during spraying. This was tested with both types of sprayer, the operator moving his body so as to give five vigorous sideways shakes in the 5 sec. before spraying and at 3 min. and 6 min. after beginning to spray. Hall[2] suggested frequently inverting the machine and, although the method seemed impracticable, it was compared with shaking, using the pressure-retaining sprayer and inverting it for 5 sec. periods at the 3 min. time intervals.

Results

All results are expressed as the mean of two tests in which excellent replication was obtained.

The spraying rates of the standard unit and the corresponding nozzle pressures are illustrated in Fig.1. Without a pressure-regulating valve both the nozzle pressure and the output of water dropped rapidly during the first 2-3 min. and continued to fall throughout the spraying period. After 10 min. there was a nozzle pressure of only 5lb. per sq.in. and a mere trickle of liquid although about 20% of the original water remained in the container. When a pressure-regulating valve was fitted it was effective only for about 2 min., i.e. until the pressure in the container fell below 30lb. per sq.in.

Fig. 2 shows the spraying rates and pressures recorded for the pressure-retaining machine with and without a pressure-regulating valve. Without the valve, nozzle pressure dropped from 90 to 30lb. per sq.in. in about 6.5 min. and fell sharply to zero in the next 30 sec. as the container emptied. During this 7 min. period the water output fell from about 790 ml in the first 30 sec. to about 335 ml in the last 30 sec. Excellent results were obtained, however, when the pressure-regulating valve was fitted; the spraying time was increased to 8.5 min. and throughout this period the nozzle pressure was constant at about 30lb. per sq. in. and the water output at about 520 ml per 30sec.

When the water-dispersible powder was used with the standard sprayer (Fig. 3) gross changes occured in the weight of solids sprayed during the 10 min. period. The combination of high output of liquid and rapid settling of solids led to an excessively high initial output of solids. After 7 min., however, the output consisted of almost clear liquid.

The pressure-retaining unit sprayed a suspension effectively for only about 4 min. Fig. 4 shows that an initial overdosing occured and that this was followed by a rapid fall when for a short period the spray contained a negligible amount of insecticide. The increase in the solids content of the spray during the last 60 sec. almost certainly resulted from the draining off of material which had settled on the bottom of the container. The addition of a pressure-regulating valve reduced the initial spraying rate and consequently increased the effective spraying time by about 1 min. (Fig. 5).

The DDT determinations made on the sprayed solids showed that little if any separation of DDT from the carrier had occured, the proportion of DDT to carrier remaining reasonably constant therefore throughout the spraying periods.

Fig. 6 shows that agitation of the pressure-retaining sprayer reduced the degree of sedimentation and that, although considerable variations in concentration occurred, the extremes were avoided. Inversion of the machine had only slight advantage over sideways shaking.

The high initial output rate of the standard pneumatic sprayer largely counteracted any effect of agitation and no worth-while improvement was recorded.

Discussion

When pneumatic knapsack sprayers are used, a constant output of liquid can be maintained only by using a pressure-retaining unit fitted with a pressure-regulating valve. With this equipment it should be possible to obtain uniform spray application with a solution or with a stable emulsion provided that the nozzle is held at a standard distance from the surface, remains at a constant angle and is moved at a uniform rate.

Unless a constant spraying rate is maintained, uniform spray application is entirely dependent on visual assessment of deposits and can be obtained only by varying the speed of movement and the distance of the nozzle from the target. For example, with the standard pneumatic sprayer the operator needs to move the nozzle about 3 times more quickly in the first 30 sec. of spraying than in the last 30 sec. and at the same time must bring the nozzle increasingly nearer the target in order to compensate for the decreasing throw of spray associated with the falling pressure.

It is obvious that most operators are unlikely to be able to exercise such careful judgement and that gross variations in deposit will occur. Thus, in a single treatment under-dosing in one place may result in inadequate control of insects while over-dosing elswhere may result in damage to commodities and the deposition of residues above the accepted limits.

In practice most sprays are diluted to give the required deposit of insecticide at the dosage rate of 1 gal per 1,000 sq.ft. and, in this investigation, the rates of spraying were controlled at a level which would enable an operator to achieve this. It is our view, however, that with stable suspension, more concentrated insecticides could be applied in practice so that a greater area could be treated with a given volume of liquid and less wetting of walls and commodities would occur. In order to maintain uniform deposition a nozzle with reduced throughput should then be used rather than an increase in the speed of movement of the nozzle over the target. An added advantage of this method would be the longer spraying period achieved for each charging of the container.

In general, pneumatic knapsack sprayers cannot be recommended for the application of water-dispersible powders but, where the product used is known to have good properties of suspension, a reasonably even deposit should be obtainable by using the pressure-retaining sprayer fitted with a pressure-regulating valve; provided of course that there is no delay between charging the machine and spraying.

Conclusions

1. Considerable variations in rate of spraying, and therefore in deposits, occur when pneumatic knapsack sprayers are used.
2. A constant, liquid output can be obtained by using a pressure-retaining, pneumatic sprayer fitted with a pressure-regulating valve. With this apparatus it should be possible to obtain uniform deposits of solutions or stable emulsions if the rate of movement, angle of spraying and distance from the target remain constant.
3. Where water-dispersible powders are used, the rate of sedimentation may result in major variations in the deposit of insecticide being applied, so that gross errors in dosing occur.
4. In general, pneumatic sprayers are not recommended for the application of water-dispersible powders but, with products having good properties of suspension, reasonable results should be obtained by using a pressure-retaining sprayer fitted with a pressure-regulating valve. Some improvement of performance can be effected by agitating the contents of the container during the spraying operation.

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AN INTRODUCTION TO WOOD PRESERVATION

This article is intended as a brief introduction to the subject of timber preservation and to provide a background for the articles which are to follow on the main chemicals used in the formulation of organic solvent type preservatives.

By W. E. Bruce,* M.A., F.I.W.Sc.

WOOD WAS THE FIRST constructional material used by man and since the Stone Age he has used it for tools, weapons, fuel, craft, furniture and buildings. Almost all the numerous industries which have been developed since prehistoric times depend to a greater or lesser extent, directly or indirectly, on the availability of timber. Wood remains a pre-eminent material for constructional work and many other purposes. The properties generally sought in a timber are ease of working, mechanical properties suited to the purpose for which it is to be used and weight per cubic foot as low as possible compatible with the strength required. It happens on occasion that these properties are found together in timbers which are not resistant to decay, infestation by insects and injurious animal organisms. Therefore it is advisable that such timbers should be effectively treated with preservative if they are to be used economically, with a minimum expenditure on repairs and replacements under conditions favourable to fungi or destructive insects.

It is not suggesting that all timbers should be treated, for some species are resistant even when used outdoors or in other places favouring insect or fungal attack, but it should be remembered that timbers of different species vary greatly in their durability. For information on this subject reference should be made to 'A Handbook of Hardwoods' and 'A Handbook of Softwoods' prepared by the Forest Products Research Laboratory and obtainable from H.M.S.O. Durable species are, however, often relatively costly or possibly in limited supply and may be less economical to use than a non-durable species which has been efficiently treated with a suitable preservative.

* *Secretary, British Wood Preserving Association*

Agencies of Deterioration

Causes of deterioration are:—

(a) Wood-destroying organisms such as fungi, insects and marine animals,
(b) Fire,
(c) Chemicals, (strong acids and alkalis may decompose certain constituents of wood causing disintegration)
(d) Weathering, (this is the mechanical and chemical disintegration of the surface of the wood caused by alternate shrinking and swelling under different weather conditions and also probably by the action of sunlight),

Fungal Attack

The sapwood of timbers and to a lesser extent the heartwood of many timbers used in structures are liable under certain conditions of moisture content and of temperature and humidity of the air to be attacked by wood destroying fungi and/or insects. The present day tendency to use smaller, more highly stressed structural members increase the importance of protection against wood destroying agencies. If a building is properly designed, correctly built and efficiently maintained, fungal attack should not occur since the moisture content of the timber should not exceed 20% and this is generally regarded as the critical moisture content beyond which or about which the germination of fungal spores may take place. Unfortunately in so many cases maintenance falls short of what is desirable. The principal fungi likely to attack timber in buildings are *Merulius lacrymans* (Dry Rot) which normally attacks soft woods, but which having established itself in a softwood may spread to hardwoods, *Coniphora cerebella* (Wet Rot or Cellar Fungus) which attacks softwoods

and hardwoods and certain *Poria* species attacking softwoods. Timbers buried in the ground, for example fence posts and transmission poles, are subject to very damp conditions and unless a naturally durable timber is used should be given preservative treatment. Even where such timbers as European oak, sweet chestnut and western red cedar are used, if sapwood is included preservative treatment is to be recommended.

There is also a different sort of fungi which may attack timber used for marine work or used in the 'fill' of cooling towers. This is commonly referred to as 'Soft Rot' covering various species of *Ascomycetes* and *Fungi Imperfecti*. It may attack both softwoods and hardwoods. Soft rot occurs under permanently or recurrently damp or wet conditions and in the early stages is difficult to detect except by microscopic examination, although there is a definite softening of the wood structure. In timbers for marine work the area most likely to be attacked is that between high and low water levels. Soft rot may also occur in timbers used for purposes other than the two mentioned and in a paper presented at the B.W.P.A. Annual Convention in 1955, J. G. Savory mentioned attack occuring in transmission poles, fence posts, boats, mill wheel paddles, greenhouses and buildings.

Insect Attack

Although it is possible to detail certain conditions under which fungal attack may take place it is more difficult to set out the conditions under which insect attack will occur. It can, however, be said that millions of pounds are spent annually on the curative and remedial treatment of timber *in situ* suffering from fungal and insect infestation. The principal wood boring insects which may attack timber in this country are *Anobium punctatum* (Common Furniture Beetle) which attacks the sapwoods of hardwoods and softwoods and sometimes bores into the heartwood, *Xestobium rufovillosum* (Death Watch Beetle) which normally attacks hardwoods though softwoods are not immune from attack (both sapwood and heartwood may be attacked), *Lyctus* spp. which attack the sapwood of partially seasoned hardwood timbers the pores of which are large enough to admit the ovipositors of the females for egg laying and *Hylotrupes bajulus* (House Longhorn Beetle) which attacks the sapwood of softwoods. Leaflets giving detailed information on these insects and on fungi have been prepared by the forest Products Research Laboratory and the British Wood Preserving Association.

Marine Borers

Timbers for marine work are liable to attack by marine borers if used in salt or brackish water. The principal organisms are ship worm (*Teredo spp.*) and gribble (*Limnoria spp.*). For detailed information, reference should be made to F.P.R.L. Leaflet No. 46, "Marine Borers and Methods of Preserving Timber against their Attack". No timbers are completely immune from attack by shipworm and gribble although the heartwood of certain species has been found to offer satisfactory resistance to attack, e.g. jarrah, turpentine, ekki, okan, Basra locus and greenheart.

Attack by ship worm occurs around the coasts of Great Britain, south of the Clyde but mainly around the southern half of England. It is also found in tidal rivers. Gribble attack occurs in the waters all around the coasts of Great Britain. Certain authorities have indicated that they believe there to be a relationship between the incidence of soft rot attack and attack by gribble and that if protection can be given against 'soft rot' attack the danger of attack by gribble would be reduced.

Termites

Termites are the most injurious wood feeding insects in the world. More than a hundred different species are known to damage buildings and wooden structures, not only in the tropics but in certain warm, temperate regions, as for example in parts of the United States of America. W. V. Harris in the 1960 Wood Preservation Supplement stated that apart from mountain areas more than 8,000 feet above sea level, it would not be safe to assume that there was any country within forty degrees either side of the equator where there was not risk of termite damage. Very occasionally they have been introduced into the United Kingdom with imported timber or in packing materials, but they have not become established and are not known as timber pests in this country. Detailed information on "Termite Proofing of Timber for use in the Tropics" will be found in F.P.R.L. Leaflet No. 38.

Early Timber Preservation

Since wood was the first constructional material used by man, it is inevitable that throughout the ages much thought has been given to the problems of protecting wood from biological attack by fungi, insects and marine borers. From earliest times people searched for means by which to prolong the service life of wood when used under conditions where hazards existed from destructive organisms. In early buildings wooden pillars were placed on stone blocks to protect them from the dampness of the soil and the tops of these pillars were covered by a slab or tile to keep off the rain. Tar and pitch were used for painting wood from earliest times as were oils from olives, cedar, larch, juniper and the nard-bush. These substances were applied to give

Photo: Preservation Developments

Serious timber destruction by combined fungal decay and insect attack.

protection against decay and insect attack. More than a century B.C. the Chinese immersed building timbers in sea water or in the water of salt-lakes. Alexander the Great ordered piles and bridging timbers to be covered with olive oil as a precaution against decay and the Roman Emperors issued similar edicts for all constructional timbers exposed to severe conditions of moisture. The Temple of Diana was built on charred piles and in the famous statue of Diana of Ephesus holes were bored into which nardus oil flowed continually from a vessel placed above the statue. The wooden image of Jupiter at Rome was impregnated with olive oil and cedar oil and the statues of Minerva and Bacchus with oil of spikenard.

A British patent of 1625 refers to a preservative to be used for the treatment of ships timbers to give protection against rot, shipworm and fire. In the U.S.A. the earliest recorded patent was granted in South Carolina to Crook in 1716. This preservative was to protect ships' planking against shipworm and decay and one part of it was the oil or spirit of tar.

The early efforts to preserve wood were not outstandingly successful because the real causes of wood decay were not fully known or understood. It was only after the investigations of Pasteur and Koch that destruction by micro-organisms and insects came to be studied on a more scientific basis. Wood preservation consists essentially of incorporating in the timber chemicals which are to prevent or at any rate greatly retard the particular attack being combatted. Complete penetration of the wood is not always necessary provided that an outer layer of sufficient depth is impregnated with the preservative. This layer must be of such thickness that any slight cracks or mechanical damage to the surface will not expose the inner untreated wood.

Tar Oil Type Preservatives

Creosote oil has been widely used in this country as a timber preservative for well over 100 years. Bethell took out his patent in 1838 for the application of creosote oil according to the vacuum and pressure process. Creosote oil is a distillation product of coal tar and in Great Britain today its use is covered by two British Standards:—

a) B.S. 144:1954 "Coal Tar Creosote for the Preservation of Timber".

b) B.S. 913:1954 "Pressure Creosoting of Timber".

Tar oils other than creosote are covered by British Standard B.S. 3051:1958. Detailed information about creosote will be found in B.W.P.A. Leaflet No. 8, "The Use of Creosote Oil for Wood Preservation". and in a brochure on Creosote available either from the offices of the British Wood Preserving Association or the offices of the Association of Tar Distillers.

Water-borne Preservatives

The efficacy of water-borne preservatives has been realised in certain quarters for over 250 years but as early as 1705 Homberg recommended mercury chloride for wood preservation. The early forms of water-borne preservatives were, however, seldom fixed in the timber to any extent and therefore their use was limited as they were efficient only where there was no danger of leaching. It is only in the past thirty years that this type of preservative has been used to any considerable extent in Great Britain. The modern formulations are generally well fixed in the timber and cannot be leached out when exposed to severe conditions of high humidities or even running water.

Among the early water-borne preservatives used were copper-sulphate, magnesium silico-fluoride, mercuric chloride, sodium fluoride and zinc chloride. Copper sulphate was recommended by De Boissieu and Bordenave in 1767 and by Wade in 1815. In 1837 Margary took out a patent for the use of sulphate and acetate of copper. Mercuric chloride originally used by Homberg in 1705 to preserve wood from insect attack was recommended in 1767 by De Boissieu and in 1730 the Dutch government used it unsuccessfully on wood immersed in sea water to give protection against *Teredo navalis* (Shipworm). Davy recommended its use in 1824 and Kyans' first patent for its employment for wood preservation was taken out in 1832. Zinc chloride was recommended by Wade in 1815, by Boucherie in 1837 and Sir William Burnett took out a patent for its application in Great Britain in 1838. Magnesium and zinc silicofluorides are used to some extent in Germany as is sodium silico-fluoride in the U.S.S.R. Sodium pentachlorphenate is widely used for dipping unseasoned

timber to prevent infection by certain fungi. Sodium-ortho-phenylphenate has also been introduced for the same purpose.

Today in Great Britain the water-borne preservatives most widely used which give good fixation are those of the copper/chrome, copper/chrome/arsenic types. Also used to a lesser extent is a preservative of the fluor/chrome/arsenate/phenol type which does not give such good fixation. There is also one firm using a mixture of zinc chloride and aluminium sulphate. These preservatives are normally applied by vacuum pressure impregnation. Preservatives of this type used, in addition to those already mentioned, in other countries include boron compounds, chromated zinc chloride, copperised chromated zinc chloride, zinc/chrome/arsenic, zinc/copper/chrome/arsenic and zinc meta arsenate.

Detailed information on the water-borne preservatives will be found in B.W.P.A. Leaflet No. 10, "Use of Water-Borne Preservatives for Timber". and in the blue booklet on "Timber Preservation" published jointly by the British Wood Preserving Association and the Timber Development Association. A paper on 'Boron as a Wood Preservative' by D. R. Carr, will be found in the B.W.P.A. 1959 Annual Convention Record.

The B.W.P.A. has already issued standards for water-borne preservatives of the copper/chrome and fluor/chrome/arsenate/phenol types and these are now being prepared as British Standards by B.S.I. Technical Committee WPC/4.

Organic Solvent Types Preservatives

The toxic ingredients in organic solvent type preservatives are dissolved in volatile solvents such as white spirit, naphatha or light petroleum distillates or in relatively non-volatile petroleum fractions such as diesel oil or gas oil. Almost all organic solvent type preservatives are based on pentachlorophenol, copper or zinc naphthenates, chlorinated naphthalenes or combinations of these chemicals. Copper and zinc naphthenates have been used as wood preservatives for some fifty years. The chlorinated naphthalenes were first investigated as wood preservatives forty years ago, whereas phentachlorophenol was first developed as a wood preservative in the United States in the early 1930s. Today we find in use zinc and copper chlorophenates. Other preservatives of this type, though in more limited use for wood preservation, are phenyl mercury oleate, pentachlorophenyl laurate and ortho phenylphenol.

In Great Britain this type of preservative is usually applied by steeping, dipping, brush or spray, although in the United States and certain other overseas countries where petroleum solvents are relatively inexpensive, solvent type preservatives are applied by pressure impregnation.

For the treatment of timber *in situ*, particularly where insect attack has taken place, it has become common practice to reinforce the insecticidal properties of this type of preservative by the addition of small quantities of potent insecticides such as the gamma isomer of benzene hexachloride, DDT and dieldrin. The extract commonly known as pyrethrum is also incorporated in insecticides of all types, including some woodworm fluids.

During the past twenty-five years, particularly in the United States, use has been made of organic solvent type preservatives of the water repellent type, particularly for the treatment of joinery timber. In 1945 the Forest Products Laboratory at Madison published "A survey of the properties of commercial water-repellent and related compounds" by F. L. Brown and L. W. Downs, which has proved the basis for most of the developments since that year, and a paper on this subject appeared in the Wood Preservation Supplement, June 1960. This particular type of preservative has come into use in the United Kingdom mainly during the past ten years.

Recently chorinated paraffin wax has also been used for timber preservation. It is compatible with other chlorinated and organic chlorine compounds and can be used in admixture with chlor-phenol and chlor-benzene compounds to increase its toxicity to fungi and insects.

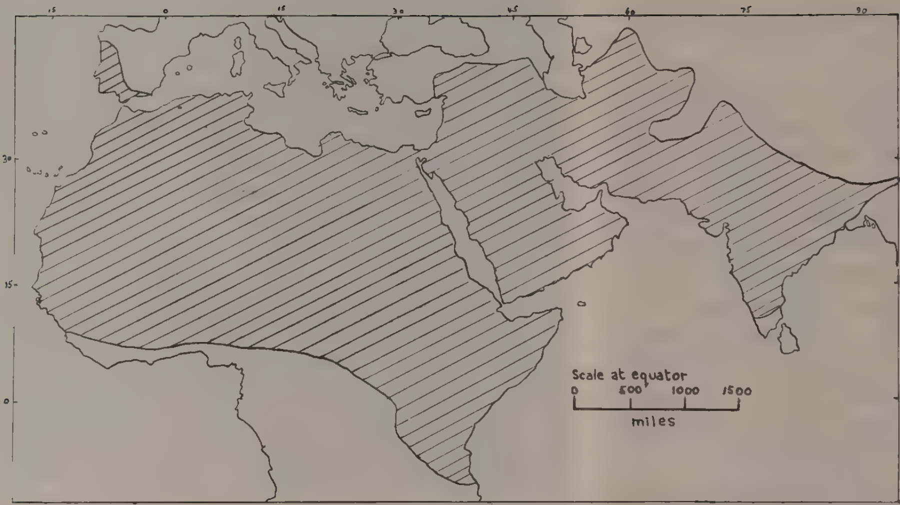
More detailed information on organic solvent types preservatives will be found in B.W.P.A. Leaflet No. 9 "Wood Preservatives of the Organic Solvent Type", and the following papers may be of interest to the reader who desires to study further this type of preservative:—

B.W.P.A. Convention Record 1954–"Solvent Type Preservatives" by Ira Hatfield.

B.W.P.A. Convention Record 1955–"The Development and Use of Naphthenates for Timber Preservation" by R.A. Bulman.

Conclusion

In speaking of the wood preservation industry it should be remembered that there are two forms of treatment. The first is the pre-treatment of timber before it is put into use and the second is the remedial and curative treatment of timber *in situ* which has been attacked by fungi or insects. The need for preservation of wood will vary according to the circumstances, but where such need exists it is in the public interest that preservation should be employed. In cases where preservation has not been employed and decay or insect attack has already occurred it is equally in the public interest that *in situ* eradication treatment be applied as quickly as practical in the circumstances.



Anti Locust Research Centre Survey of the Invasion Area of the Desert Locust

THE DESERT LOCUST *(Schistocerca gregaria)*

AN INTERNATIONAL PROBLEM OF CONTROL

By R. J. V. Joyce,* M.Sc., B.Sc.

THE desert locust, the eighth plague of the Pharoahs, is a problem as old as civilisation. The earliest known picture of the desert locust occurs on an Egyptian tomb of the 12th Dynasty, about 2400 B.C. and reference to damage can be found in Egyptian, Greek, Latin, Arabic and other languages down the centuries to the present day.[1] Today, the desert locust affects about 60 countries and territories in Africa and south-western Asia, from Mauritania to Pakistan and the Food and Agricultural Organisation of the United Nations estimates that control operations cost governments at least £4,000,000 annually, though this may be £10,000,000 during years of high locust activity.[2]

Some other insects have an equally wide distribution, but it is characteristic of the desert locust for whole populations to move over vast distances. Recent analysis has provided evidence on the range of these migrations. Swarms were seldom found to breed less than 500 miles from their birthplace, and displacements of 2,000 miles within a single generation were common. The distance which may be covered in a single flight is provided by records of desert locusts in the Atlantic some 1200 miles from the nearest land.[3]

Two great zones of seasonal breeding have recently been distinguished,[4] :-

1. *The summer-winter breeding zone:* this runs from Senegal through western and equatorial Africa, to Sudan Republic, northern Ethiopia and southern Arabia, and on to Pakistan and India where breeding occurs between July and October, and includes a smaller area where breeding occurs between November and January, more frequently on the Red Sea and the Somali peninsula littorals than elsewhere.

2. *Spring breeding zone:* in this breeding takes place between January and June; it includes north-western and northern Africa, Saudi-Arabia, United Arab Republic and extends east as far as Pakistan and south to British East Africa.

When mapped, the Spring breeding zone is seen to be peripheral, and the summer-winter breeding zone central. Movement of populations between these zones occurs seasonally, and each zone is regularly free of swarms and breeding for months at a time. Movements are considered to take place towards and with zones of air convergence which are defined as areas across the boundaries of which surface winds flowing in exceed those flowing out, resulting in overall vertical movement of air, a condition essential for the production of wide-scale precipitation.[5] This hypothesis provides an elegant explanation of why the desert locust, an inhabitant of areas of sparse and variable rainfall, is able to migrate between areas of summer and spring rains, taking advantage in each of suitable breeding conditions.

* Mr. Joyce is a member of the Desert Locust Survey in Nairobi.

Photo: Courtesy Fisons Pest Control.

Close-up of a fully grown hopper.

Photo: By A. C. V. Everard of the Anti Locust Research Centre.

A Section through a Flying Swarm.

The Interdependence of Control

It is thus that all parts of the whole distribution range are intimately linked, so that an event in any one part may affect, directly, or after a single generation, any other part of the range.

Movements of major zones of convergence and therefore of locust populations, though broadly predictable seasonally, are subject to wide unpredictable variations, so that even the most frequently infested countries may, on occasion, be free from invasion for several successive years, and breeding in one country result in unexpected invasion of another.

Where these population movements consist of widely scattered individuals, it is probable they would be of slight economic importance. It is, however, characteristic of the species to move in swarms of high population density, which maintain their identity for months on end in spite of the disruptive processes of the atmosphere which could disperse in a few hours a collection of inanimate particles of similar total mass[6].

The numbers of insects which these swarms represent have been estimated on several occasions. Gunn *et al*[7] calculated volume densities of 14 locusts/m^3 in the Kenya Highlands in 1945, the swarm being 10 m. deep, namely of stratiform structure. Far lower densities are characteristic of cumuliform swarms, 0.1 locusts/m^3 being a typical figure, though densities as high as 0.7 locusts/m^3 may be common in other places, such as the Somaliland Protectorate or Sudan Republic, the swarms under these conditions flying to several thousand feet[6].

An analysis (*Joyce, R. J. V. unpublished*) of the locust invasion of the Somali peninsula from 1955 to 1958, was revealed by aerial reconnaissance in which measurements were made of swarm size, gave an estimate of over 6,000 sq. miles. Nearly 50 per cent. of the total recorded swarm coverage was by large swarms of over 24 sq. miles in size and nearly 70% was by swarms over 13 miles in size. Swarms of less than 6 sq. miles made an unimportant contribution to the total coverage. About 50% of the swarms were described as thin, 35% of medium density and only 15% were dense swarms. No objective measure of the density was possible on these occasions but these invasions represent a total of at least 100,000 million or 200,000 tons of locusts. Similarly Rainey[3] measured some 50 swarms with a total area of about 500 sq. miles, as they entered Kenya in 1954. From objective evidence of the density of these swarms, the number of insects involved was estimated at 50,000 million or 100,000 tons of locusts.

Laboratory data[8] show that locusts, when actively flying, can be expected to eat their own weight of green food daily. Most of this food is provided by wild vegetation but these numerical estimates help to explain the devastating damage which can occur when locust swarms invade crop areas. Thus, in 1954, some 1,000 miles^2 of swarms were estimated to have entered the highly cultivated Souss Valley of Morocco and the damage to crops and orchards was officially estimated at £4½ million[9]. These swarms probably bred several months previously in the equatorial parts of Africa over 2,000 miles away. More recently, in 1958, it was estimated that 167,000 tons of cereals were destroyed by locusts in Ethiopia[4]. It could be inferred from meteorological data and swarm

reports that at least some of the locusts responsible had bred during the summer rains in Eritrea and Sudan, fledging in early September. They moved south along the edge of the Dessie escarpment of Ethiopia reaching the Giggiga plains in October, and Somalie in November, as a single swarm covering over 300 sq. miles. These same populations subsequently entered northern Kenya and bred in April 1959, some 8 months after fledging, having travelled over 2,500 miles from their birthplace.

Organisation of Control

The interdependence of territorial locust control must thus be recognised as the basis of successful control. This has important practical effects for, though some countries which are producers of locust swarms, have little agriculture, others with valuable crops receive swarms from the former. For example the rich crop production of Algeria and Morocco may receive swarms bred in the deserts of the Chad and Sudan, while swarms bred on the Spring rains in the deserts of Saudi-Arabia may travel to India, Pakistan, Syria, Israel, Egypt and eastern Africa. Control efforts based solely on national organisations, whose strength must depend on the agricultural interests of the country, cannot hope to be commensurate with the importance to the whole invasion area of breeding which from time to time occurs. The Panel of Experts convened by F.A.O. to study this problem concluded that, while all affected countries should maintain national anti-locust organisations which should never be totally disbanded, even during periods of plague recession, not only should all countries be prepared as far as possible to assist neighbouring countries in locust control but also an adquate international mobile strategic control reserve should be available as a striking force to concentrate effort when and where it was possible to achieve the greatest impact on the overall situation.

This need for mobile control forces to supplement national efforts, reinforcing the technical requirements imposed by the nature of the problem itself, has had a powerful influence on the development of new control methods.

Principal Current Methods of Control

Probably the most widely practised method of locust control is by the use of poisoned bait against the immature stages. An insecticide, gamma BHC, dieldrin, aldrin, etc., is mixed at about 0.1% concentration of active ingredient with an acceptable carrier, such as wheaten bran which is spread before and amongst marching hopper bands. The results are frequently very striking, the marching hoppers of all instars usually halting and feeding on the bait, often dying *in situ* a few hours later. Under favourable conditions an extremely high-efficiency in use of insecticide can be achieved with poisoned bait—that is, the number of locusts killed as a percentage of the lethal doses applied. In small scale field trials against 111 instar hoppers, Rainey[3] recorded an efficiency of 44% in the use of insecticide. In larger trials against the same instar C. Ashall (unpublished) had efficiences ranging from about 4 to over 30%. The rate of application varies from about 20 lbs.[10] to about 150 lbs. per acre of hoppers in accordance with the hopper density and instar. This means that a population of hoppers sufficient to produce a 100 mile^2 swarm would need for its control about 4,000 tons of bait if attacked in V instar or about 100 tons if attacked in I instar, and the bait used at maximum efficiency. This calculation emphasises not only the need for such control campaigns to be designed to attack I instar hoppers, but also the magnitude of the effort required to operate a baiting campaign if such early treatment is not possible. Usually, of course, bait, which is spread by unskilled labour, is not used at maximum efficiency, nor is it always possible to prepare for the type of infestation which can generate 500 sq. miles of swarm. In practice, baiting campaigns against large-scale infestations frequently develop so that the bulk of the bait is expended against later instars, resulting in the enormous demands on transport and organisation which the distribution of 3,000—10,000 tons of material in desert areas inevitably entails. The method, then, though capable of high efficiency especially in small campaigns prepared with foresight, is admirably suited as the basis of national effort but demands movement of too much bulk to enable the maximum potential control reserve to be concentrated where it is most needed, namely to deal with situations that cannot be foreseen.

Low Volume Applications

Since in poisoned bait only 0.1% of the material transported is insecticide, efforts have been made to apply concentrated insecticides to the vegetation on which hoppers feed, thus avoiding the use of costly and bulky insecticide carrriers. The application in this way of a persistent insecticide would moreover enable successive lots of hoppers to be killed. A suitable insecticide for this type of application is dieldrin, for which laboratory data has indicated a median lethal dose of 5μg/gm of V instar, roughly half this for I instar (R. D. MacCuaig unpublished) and a persistency of toxicity on vegetation in the field of at least 26 days[11]. A machine, the Exhaust Nozzle Sprayer, particularly well suited for the application of such insecticide concentration, designed by H. J. Sayer, utilises the exhaust gases of the vehicle, usually a Land Rover, at a pressure of 3—5 lbs./in^2 to break the spray liquid into droplets of mmd of 70μ. These are allowed to drift downwind and are largely selectively collected by the vertical surfaces of vegetation, rather than on the horizontal surfaces of bare ground which constitutes so much of the habitat of desert locust hoppers.

Field trials in Libya, Eritrea, Ethiopia and other countries have resulted in excellent kills of all instars when 20% dieldrin spray in a non-volatile oil were emitted at 8—10 litres per Km. (3—4 gals. per mile), the vehicle travelling at 8 km. per hour (5 m.p.h.).

This technique of vegetation baiting results in an enormous increase in control potential, so that a single operator with a vehicle fitted with an exhaust nozzle sprayer has the means of applying in a day the insecticide which, in the form of poisoned bait, would require 1,000 labourers. The best means of utilising this increased control potential has yet to be investigated. Thus, target baiting of spraying depends for its success on what is, in effect, a 100 per cent. inspection scheme applied to the whole area likely to contain infestations. In practice each operator may be responsible for several hundred or over 1000 sq. miles of country more or less difficult of traverse, and the control potential available particularly in respect of the persistency of toxicity can be best exploited if the spray can be laid so that successive hopper populations can be caused to feed on the same sprayed vegetation. This conception of Barrier Spraying involves the assumption that the discovery of a single hopper band provides a high degree of chance that a large area of country is infested beyond a tolerable level and all should be treated with appropriately spaced spray lines without further inspection. Studies made of the distribution of hopper bands in northern Kenya (*Joyce, unpublished*) showed that if a single band were found in a random search in 10 per cent. of an area. there was a 99.5% chance that the whole area was infested. Moreover, studies in the Somali peninsula (*Joyce, unpublished*) indicated that if in any season a particular area were selected for oviposition, there was a greater probability than could be expected from chance that further oviposition would take place in the same locality. The nature of the distribution of locust hopper populations therefore deserves close study in calculating the most efficient use of persistent insecticide concentrates as vegetation baits. Moreover, there appears to be no basic reason why such sprays should not be applied equally well but more economically by aircraft.

Control of Locust Swarms

It is in the adult flying stage that the desert locust spends the greater part of its life and during which it causes its most spectacular damage. In a few areas swarms are sufficiently static to be vulnerable to ground operations and substantial destruction of such swarms has been recorded, for instance on the Red Sea littoral of Sudan Republic by means of posioned bran or groundnut husk bait, and in parts of the Somaliland Protectorate using spray concentrates as contact poison, (*Joyce, unpublished*). However, over most of the invasion area the mobility of swarms, which may cover 70 miles in a day, is such as to preclude the use of ground control as an effective weapon. Aircraft alone have in practice been

Photo: Courtesy Shell.

Fitted to the back of a Land Rover, the Evers & Wall Exhaust Nozzle Sprayer spreads insecticide over the desert.

found to have the mobility and control potential adequate to deal with these large highly mobile targets. experience has shown that swarms may under favourable circumstances be visible from the air up to 60 miles away[3] and aerial reconnaissance has proved to be the only reliable means of establishing the size of a locust invasion.

The use of aerial spraying for swarm control was recently exhaustively reviewed by Rainey[3]. In practice it has been found necessary for the most efficient use of insecticide to spray swarms when they present themselves at their highest volume density and while in flight. This is usually during the late afternoon or early evening. Moreover, when spray is applied at this time some of the insecticide which fails to hit a locust stands a good chance of falling onto vegetation of the roosting site where it may subsequently become effective through stomach action. The implementation of this technique requires the application of as many toxic doses as possible in a period of time often as short as 30 and rarely as long as 120 minutes. About half the swarm coverage reported for instance during the past four years in eastern Africa was accounted for by swarms of over 24 mile^2 containing possibly some 3×10^9 locusts and in practice an efficiency in use of insecticide can rarely be expected to exceed 2 per cent., then an aerial spraying unit must be able to apply at least 200×10^9 LD 50 doses in the short time available for spraying. This represents about 7,000 gals. of 11% gamma BHC or 3,000 gals. 20% dieldrin or about 700 gals. 85% diazinon. This illustrates the importance of using highly concentrated insecticides as the only practical means of applying in the limited time available the number of toxic doses dictated by swarm size. British teams consisting of 2 spraying Beaver aircraft have, in fact, sprayed 2,000 gals. per day on swarms at their optimum structure in Somaliland Protectorate and 20,000 gals. in a single month of spraying with evidently entirely satisfactory results. This unit has also been able to operate from successive bases in 5 different territories and, with adequate advance preparation, be operational within hours of arrival at the new base.

Evidently a 3 Beaver unit suitably equipped and operating from prepared and stocked bases possesses a control potential and mobility suited for operations on an international basis at least within a limited region of the desert locust distribution area.

Conclusions

This account emphasises the territorial interdependence of locust control and the need for a highly mobile control reserve to supplement national efforts at times and places demanded by the current locust situation. The development of aerial application of insecticides to locust swarms and to vegetation for the control of hoppers is of major importance in satisfying this need with a weapon of adequate mobility and power.

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NEWS AND NOTES

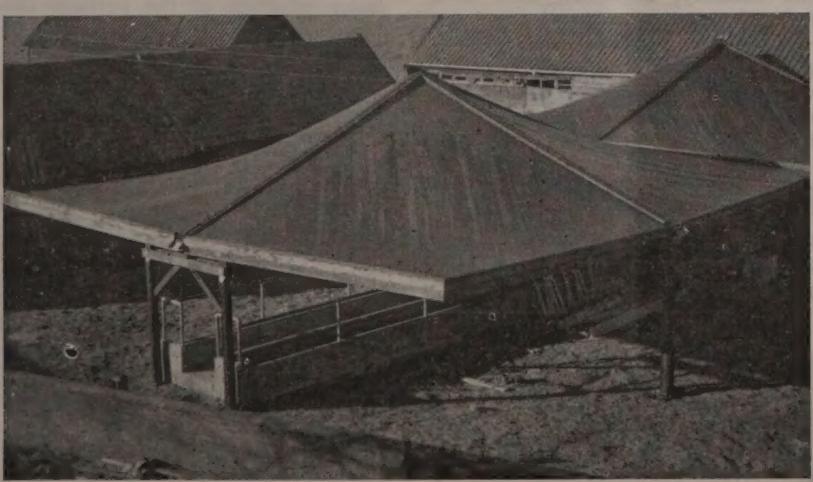
Burt Boulton & Haywood to Market Prefabricated Hyperbolic Paraboloid

A new venture for Burt Boulton and Haywood Ltd., well known manufacturers of agricultural chemicals for formulators and farmers, is the introduction of a new type of farm building which is described as the "Rolls Royce of Farm Buildings".

The unique construction of the building—a hyperbolic paraboloid shell roof supported on round transmission poles—offers clear space in both the loft and floor areas to an extent unobtainable in traditional designs. In the standard unit the multisection roof of scandanavian redwood boarding covers 2,400 sq.ft. and is supported by four Scots fir transmission poles. The covered area can be increased by adding further standard units and a wide variety can be obtained by adding different sized standard units together.

As one would expect from the firms' interest in timber preservation all parts of the building are treated with a preservative before assembly. Where a building is to be painted the recommended treatment is pressure impregnation with Tanalith 'C' water borne preservative to give a dry salt retention of 0.5lbs/cubic foot in the transmission poles and a retention of 0.33 lbs dry salt/cu. ft. in sawn timber. When the building is not to be painted pressure impregnation with creosote is carried out in accordance with B.S. 913 to give the poles a net retention of 7-8lbs. of Creosote Oil/cu. ft., and the sawn timber a net retention of 6lbs. Creosote Oil/cu. ft.

In certain cases where a building is urgently required the roof is brushed with copper napthenate.



The prefabricated hyperbolic paraboloid farm building marketed by Burt Boulton & Hayward

1959 Agricultural Machinery Census for England and Wales

Of the machines and implements owned in 1959 by occupiers of agricultural holdings, agricultural contractors and divisional office trading services of the Ministry it is estimated that 57, 280 were spraying machines, 8,200 of these were power fruit sprayers with a 50 galls. or over tank capacity, other wheeled and tractor mounted sprayers accounted for the remaining 49,080.

As the estimates are based on a one third sample taken in September 1959 the figures are subject to some degree of sampling error. In the previous census, taken in 1956 it was estimated that there were 6,280 power fruit sprayers and 32,900 wheeled and tractor mounted sprayers.

Lectures on Timber pests

Last winter the Woodworm and Dry Rot Centre, organised a number of lectures on wood-boring insects and wood-rotting fungi in various towns throughout the country. In view of the fact that these lectures filled a need, particularly among professionally interested people such as architects and Surveyors, a further series is being arranged this winter to cover principle towns throughout the U.K. including Northern Ireland.

The lectures, which will be illustrated and designed to help in the detection of insect and fungal attack and to give advice on the problems of treatment, will start in October and continue to about the end of March 1961. The programme is at present being finalised and copies will be sent out to interested people. Anyone wishing details of the lectures in their areas may write to *Pest Technology* or to the Woodworm and Dry Rot Centre, 16, Dover Street, London, S.W.1.

Wood Preservation Ltd. Join British Ratin Group

The share capital of Wood Preservation Ltd., of 142 Sloane Street, London, S.W.1., has been acquired by the British Ratin Co. Ltd. of Felcourt, East Grinstead, Sussex.

Wood Preservation Ltd. are the sole agents in the United Kingdom for the wood preserving products manufactured by Desowag-Chemie GmbH of Germany. These products include the Xylamon range of preparations formulated for the preservation of timber against infestations by wood boring insects and attacks by wood-rotting fungi; Pyromors, a fire-retardent paint; and Xylacolor, a pore-filling wood preservative.

The company will continue to operate from 142 Sloane Street, London, S.W.1.

The board of directors consists of P. L. Bergin (Chairman), G. Harris, W. H. Westphal, E. M. Buchan, N. E. Hickin, Ph.D., and P. E. Allbeury.

W. J. Holmes has been appointed General Manager; T. E. Davies, Sales Manager; and J. E. Fynn, Service Manager.

The British Ratin Group of pest control companies, the largest of its kind in Europe, include Disinfestation Ltd. (incorporating Insecta Laboratories Ltd. and Scientex Ltd.), Rentokil Ltd., Woodworm & Dry Rot Control Ltd., Fumigation Services Ltd., Mi-Dox Ltd., Agricultural & Industrial Coatings Ltd., etc.

New U.S. Farm Laboratory to test Insecticides

In order to undertake research into insecticides, nematocides, fungicides, weed-killers, growth regulators and cotton defoliants, the Union Carbide Corporation is to set up a new biological research laboratory on its research farm at Clayton, North Carolina, U.S.A. Staffed by about 20 persons, half of whom will be scientists, the new laboratory will conduct basic and applied biological research for the Corporation's agricultural chemicals development programme and it is expected to be ready by August 1960. Attached greenhouses will provide additional space for test work and experiments.

At the same time, Union Carbide is expanding its research farm to approximately 300 acres, which will make it about twice its original size.

Sevin insecticide, the first major agricultural product to be developed from the Corporation's testing programme at its research farm, is now being used on cotton, many types of deciduous fruit and certain vegetables. As a carbamate, it provides control over a wide range of insects on a large variety of crops, including those insects resistant to chlorinated hydrocarbon and phosphate insecticides. It is safer to apply than many other pesticides.

The new laboratory is expected to produce further contributions in the field of farm chemicals of this type.

New Packaging Material

Though mainly of interest to the packaging industry manufacturers using or thinking of using polythene bags to pack their products may be interested in the new polythene resin —designated PY 300— manufactured by Bakelite Ltd.

This new resin is reputed to produce a standard clarity film of exceptionally high impact strength (in thickness down to 100 guage). The gain in strength should indicate a significant reduction in spoilages caused by physical damage to bags and wrappings. Bags based on PY. 300 are said to combine good opening characteristics with adequate stiffness and therefore will be easy to handle on all types of bag filling equipment.

Films based on this new polyethyene resin will be of particular advantage in the handling of hygroscopic materials.

Further details are given in Advance Information Sheet D.48 obtainable from Bakelite Ltd.

Common Names for Pesticides

The British Standards Institute have recently issued the second supplement (Ref. PD 3866) to B.S. 1831:1957 Recommended Common Names for Pesticides, listing eleven common names for pesticides. Anyone obtaining this suppliment should note that, by error, diquat has been classed as a fungicide (class 2). It is of course a herbicide (class 3). Cost of the supplement is 2/-.

Six more common names are listed in *B.S.I. News*, August 1960. Details of these chemicals will not be published in the form of a supplement but will be included in the revised form of B.S. 1831, which is due for publication in the near future.

Pyrethrum Board of Kenya and East African Extract Corporation Bury the Hatchet

The Pyrethrum Board of Kenya and the Mitchell Cotts Group in East Africa announce the conclusion of negotiations whereby all outstanding claims and disputes are amicably settled and the organisations will co-operate in the future development of the Kenya Pyrethrum Industry.

In coming to this decision, it is recognised by the organisations that the industry, in which each have valuable experience and significant stakes, has an important role to perform in the urgently needed expansion of Kenya's economy and attainment of higher living standards for its people.

Now that the world pyrethrum market can look to harmonious and stable source of supply, it is hoped that a greater potential for Kenya and Tanganyika production will progressively emerge.

Liver Fluke Disease—Prospects for the Winter.

The weather over much of England and Wales during April, May and June was very dry giving promise of another fluke-free year. Since July, however, there has been a marked change in the weather and a continuance of this wet weather during September and October is likely to produce some disease this winter. Fortunately, the onset of conditions favourable for the development of the fluke has come too late to give rise to severe outbreaks of disease such as were experienced in the winter of 1958/1959. The indications are that the season will be of an average one, with stock in flukey areas acquiring a little infection. Occasional losses in sheep can be expected on farms where the disease is known to be a problem. Losses may be slightly heavier in flukey areas in south and mid Wales and in midland counties east of the Bristol Channel.

In these areas, the fluke infection is expected to pass from the snail to the herbage in the last fortnight of September; in other areas infection of the herbage is not likely to occur until October. Flukey fields should not be grazed after these times, and stock should be kept out of such fields during November and December, also in January where this is possible.

It is well known that treatment of sheep with the standard dose of either carbon tetrachloride or hexachloroethane does not kill flukes which have been living in such sheep for less than twelve weeks. Since infection of the herbage this year is unlikely to occur before September, farmers are advised to dose their sheep in December and in January where the onset of the lambing season makes this possible.

Replacement ewes bought during the autumn whose history is not known should be dosed as soon as possible, and cattle at risk in late autumn and winter will benefit from treatment with hexachloroethane in January.

More Black Disease is expected this year than last and ewes on farms where the disesae has occured should be vaccinated during autumn in order to prevent any recurrence of the disease which may arise even under conditions of very low fluke infestations.

NEW PUBLICATIONS

Control of Rats in Sewers Ministry of Agriculture Fisheries & Food Technical Bulletin No. 10 *By E. W. Bentley. Published by H.M.S.O. London Price* 2/6d.

This bulletin will be of considerable help to local authorities and is well worth the price of 2/6d. As well as containing up to date information on control techniques it lays emphasis on the importance of planning if good results are to be expected.

Dr. Bentley starts off by giving three main reasons to justify the expense of controlling rats in sewers. First, most of the new surface rat infestations that come to the notice of the local authority are associated with defective drains. Secondly the rats can cause structural damage to the sewers and directly or indirectly, may possibly cause the blockage of drains and fracture of gas and water mains. Thirdly, rats are the principal carriers of Weil's disease, which can be fatal and which present a particular danger to sewer workers.

Following the case for control, the aspects of the biology of sewer rats are dealt with. From this section it may be noted that:-

"Rats are especially likely to thrive in the vicinity of cafes, canteens, markets and blocks of flats that have incomplete facilities for disposal of kitchen waste, in sewers that are structurally poor or that are insufficiently self-cleansing and where maintenance is neglected; and where there has been a lot of rebuilding of surface property and the old drains have not been sealed off at the sewer itself."

Various other likely 'residential areas' for rats are brought to the readers notice. Some peculiarities of the behaviour of rats in sewers which may affect control techniques are also discussed in this section.

The third section concerns the methods available for the control of rats and it deals to the greatest extent with the poisons used i.e. sodium fluoroacetate, antu, zinc phosphide, warfarin and the various methods of applying them, At present, the use of poison baits is, in general, the only practicable method of dealing with sewer rats. Types of bait, bait preservatives, application devices, timing and sequence of bait application, dosage, etc. all come in for discussion in this interesting section which also mentions the use of smoke bombs, sticky boards (coated with a water resistant adhesive containing antu) and the Schurmeyer poison-foam method.

In the last but by no means least, section of this Bulletin Dr. Bentley stresses the importance of planning control measures, stating that:-

"The task of ridding a sewer system of rats may be likened to a military operation. In the main, the factors that will determine success are the dependability of the intelligence reports received, the size and equipment of the control facilities available and the degree of flexibility that is possible in attack."

Local authorities may well find it worth their while to study this last section in particular and the bulletin as a whole.

Pest and Disease losses in Agriculture

In a contribution to the series "World Population and World Resources, currently running in the *New Scientist*, A. H. Strickland, Plant Pathology Laboratory indicates the tremendous losses in agriculture caused by pests and diseases (*New Scientist*, **8,** p. 660-662) and shows how little is known about pest and disease losses on a world wide basis. The author indicates the difficulty of making accurate estimates of both "visible" and "hidden" losses and discusses the problem of representing losses in the form of acreage equivalent lost or cash lost, both of which have disadvantages.

Mr. Strickland also says:-

"Desirable though they may be as evidence justifying the expenditure of public funds or research, loss estimates have little intrinsic value."

The reasoning behind this statement is that no one wants to know how much of his crop has been destroyed in the past but how much is liable to be destroyed in the next year if preventative action is not taken. Therefore the biologist's approach to loss assessment is to use loss estimates to predict outbreaks but as the incidence of pests and diseases is often a function of climate and weather, accurate long-term predictions must wait until meteorologists are able to provide long-range weather forcasts.

Weeder Geese—Cheaper Labour

In *California Agriculture* **14** (8), Clarence Johnson, Farm Advisory, Madera County, California gives a brief but intriguing account of the "Management of Weeder Geese in Commercial Fields." The article tells us that from 175,000 to 200,000 geese are being used in crops in California each year, and that the practice has been widely accepted and has spread rapidly since geese were first used for weeding commercial fields about seven years ago.

Apparently all breeds of geese make good weeders with white Chinese proving the most effective; young geese which are still growing are better weeders than mature birds. The greatest gaggle of geese are used as a cheap means of controlling grassy annual and perennial weeds in cotton, but they are also utilized to some extent in vineyards, sugar beets, castor beans, strawberries, melons nursery crops, beans, hops, asparagus, potatoes, onions and for controlling reeds in irrigation ditches.

Mr. Johnson concludes his account by stating that when compared with hand labour or chemical methods in controlling weeds effecively, the saving in weeding with geese can amount to as much as 50 dollars per acre.

Probably we may soon be changing the old saying to "a bird on the land" etc.